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Executive summary for the EC (not part of this legislation)

'Venturi tube gas flow sensors' may be placed on the market and put into use in the Czech Republic as legally controlled measuring instruments in accordance with Act No 505/1990 on metrology, as amended. Pursuant to the Act, legally controlled measuring instruments are instruments, which are included in the list of the types of legally controlled measuring instruments (Implementing Decree No 345/2002) and, at the same time, intended (by the manufacturer/importer) for measurements of relevance in the protection of public interests in the fields of*consumer protection, contractual relations, imposition of sanctions, fees, tariffs and taxes, health protection, environmental protection, occupational safety or the protection of other public interests protected by special legislation*. This means that their purpose is similar to that used for defining specified products – measuring instruments and non-automatic weighing instruments – under Directives 2014/31/EU and 2014/32/EU. The requirements of this legislation do not apply to measuring instruments placed on the market in the Czech Republic for other than the above purposes defined by Act No 505/1990 on metrology.

The purpose of this notified legislation is to lay down metrological and technical requirements for legally controlled measuring instruments of the type specified above. This legislation also lays down the tests for the purposes of type-approval and verification of legally controlled measuring instruments of the type specified above.

*(End of executive summary.)*

# P U B L I C  N O T I C E

As the authority with substantive and territorial jurisdiction in the matter of laying down metrological and technical requirements for legally controlled measuring instruments and stipulating the testing methods for type-approval and verification of legally controlled measuring instruments pursuant to § 14(1) of Act No 505/1990, on metrology, as amended (hereinafter referred to as the 'Metrology Act'), and in accordance with the provisions of § 172 et seq. of Act No 500/2004, the Administrative Procedure Code (hereinafter referred to as the 'APC'), on 15 April 2016, the Czech Metrology Institute (hereinafter referred to as the 'CMI') commenced ex officio proceedings pursuant to § 46 APC, and, on the basis of supporting documents, issues the following:

# I.

# D R A F T  G E N E R A L  M E A S U R E

number: 0111-OOP-C091-18

**laying down metrological and technical requirements for legally controlled measuring instruments, including the testing methods for type-approval and verification of legally controlled measuring instruments:**

**‘Venturi tube gas flow sensors’**

The specified technical and metrological requirements are at a level comparable to that of the relevant requirements of the European standards and apply to the basic design of the Venturi tube gas flow sensor.

## 1 Basic definitions

For the purposes of this general measure, the terms and definitions pursuant to VIM and VIML[1] and the terms and definitions below shall apply:

### 1.1
### gas flow quantity measuring system

a set of one or more measuring instruments (components of measuring instruments) and, often, other equipment arranged and adapted to provide information about the qualitative and quantitative characteristics of gas

### 1.2
### Venturi tube gas flow sensor

a gas flow sensor based on the principle of measuring the difference between the pressure upstream of the Venturi tube and in its throat inserted in the defined manner into a pipe with specified geometric parameters

### 1.3
### Venturi tube

a primary element consisting of a conical convergent inlet connected to a cylindrical section (the ‘throat’) and a conical expanding section (the ‘divergent section’)

### 1.4
### pressure tapping (in the wall)

annular or circular cavity drilled into the pipe wall in such a way that the edge of the cavity is flush with the pipe’s inner surface

[1] TNI 01 0115 International Vocabulary of Metrology – Basic and General Concepts and Associated Terms (VIM) and International Vocabulary of Legal Metrology (VIML) are part of the technical harmonisation compendium ‘Terminology in the field of metrology’, which is publicly available at www.unmz.cz

**1.5**
**static pressure of gas flowing through a pipe**

pressure which can be measured by connecting a pressure-measuring device to the pressure tapping in the wall

**1.6**
**differential pressure**

difference between the (static) pressures measured at the pressure tappings in the wall, one of which is upstream of the Venturi tube and the other of which is in the throat of the Venturi tube, inserted into a straight pipe through which gas flow occurs, considering all the differences in the amounts of tappings upstream of the Venturi tube and in its throat.

**1.7**
**diameter ratio** $\beta$

the ratio of the diameter of the nozzle throat orifice to the internal diameter of the pipe upstream of the nozzle

**1.8**
**pipe Reynolds number** $Re_D$

dimensionless parameter expressing the ratio between the inertia and viscous forces in the pipe upstream of the nozzle

**1.9**
**flow coefficient** $C$

coefficient, defined for an incompressible fluid flow, which relates the actual flowrate through the nozzle to the theoretical flowrate

**1.10**
**expansion coefficient**

coefficient characterising the degree of compressibility of the fluid

# 2 Metrological requirements

During verification of Venturi tube gas flow sensors, the metrological requirements applicable when they were placed on the market shall apply.

## 2.1 Operating conditions

The operating conditions are specified by the manufacturer taking into account the range of the anticipated ambient temperatures during operation and the range of temperatures of the gas to be measured. If there are significant temperature differences between the ambient temperature and the temperature of the flowing gas, the gas flow sensor shall be thermally insulated by suitable means.

The following conditions shall apply to Venturi tube gas flow sensors for the use of the individual types of Venturi tubes:

- Venturi tube with a cast convergent section: $2 \cdot 10^5 \leq Re_D \leq 2 \cdot 10^6$
- Venturi tube with a machined convergent section: $2 \cdot 10^5 \leq Re_D \leq 1 \cdot 10^6$
- Venturi tube with a rough-welded sheet-iron convergent section: $2 \cdot 10^5 \leq Re_D \leq 2 \cdot 10^6$

### 2.2 Limits of use

Venturi tube gas flow sensors with a cast convergent section may only be used for:

- internal pipe diameter $D$: 100 mm to 800 mm
- diameter ratio $\beta$ ($d/D$): 0.30 to 0.75
- the inner surface roughness of the tube and the pipe shall comply with the specified requirements

Venturi tube gas flow sensors with a machined convergent section may only be used for:

- internal pipe diameter $D$: 50 mm to 250 mm
- diameter ratio $\beta$ ($d/D$): 0.40 to 0.75
- the inner surface roughness of the tube and the pipe shall comply with the specified requirements

Venturi tube gas flow sensors with a rough-welded convergent section may only be used for:

- internal pipe diameter $D$: 200 mm to 1 200 mm
- diameter ratio $\beta$ ($d/D$): 0.40 to 0.70
- the inner surface roughness of the tube and the pipe shall comply with the specified requirements

### 2.3 Relative uncertainty of the Venturi tube flow coefficient

Subject to compliance with all technical requirements and installation requirements, the following relative uncertainties of the flow coefficient $C$ apply to the individual types of Venturi tubes within limits not requiring the relative uncertainty of the flow coefficient to be increased by additional uncertainties:

- Venturi tube with a cast convergent section: 0.7 % ($C$ = 0.984)
- Venturi tube with a machined convergent section: 1 % ($C$ = 0.995)
- Venturi tube with a rough-welded sheet-iron convergent section: 1.5 % ($C$ = 0.985)

If straight lengths of pipe with additional uncertainty are used, this uncertainty shall be added to the uncertainty of the flow coefficient. Straight lengths of pipe carrying additional uncertainty may only be used for the section upstream of the Venturi tube.

Compliance with technical requirements shall be ascertained when verifying the individual components of the gas flow sensor and compliance with installation requirements shall be ascertained when verifying the calculator unit for the measurement of gas flow quantity.

### 2.4 Relative uncertainty of the expansion coefficient

Subject to compliance with all of the specified technical requirements, the following relative uncertainty of the expansion coefficient $\varepsilon$ applies to the types of Venturi tubes referred to above:

$$(4 + 100\beta^8)\frac{\Delta p}{p_1}\ \%$$

where $\Delta p$ is the differential pressure and $p_1$ is the absolute static gas pressure upstream of the Venturi tube.

Compliance with technical requirements shall be ascertained when verifying the individual components of the gas flow sensor.

## 3 Technical requirements

During verification of Venturi tube gas flow sensors, the technical requirements applicable when they were placed on the market shall apply.

## 3.1 Design

The basic design of the Venturi tube gas flow sensor consists of the following parts:

- the Venturi tube (with a cast, machined or rough-welded sheet-iron convergent section);
- pressure tappings;
- a stabilising straight length of pipe upstream of the Venturi tube with a minimum length of 2*D* (measured from the front end of the Venturi tube's inlet section).

The Venturi tube consists of the inlet cylinder (A) connected to the conical convergent section (B), the cylindrical throat (C) and the conical divergent section (E). The inner surface of the Venturi tube shall be rotationally symmetrical and concentric with the pipe centreline.

The design and installation of the Venturi tube shall ensure that it is not subject to plastic or elastic deformation during operation under the pressure of the flowing gas or, as the case may be, that the deformation is only within the specified limits.

The Venturi tube and straight pipe sections may be made of any kind of material with a known longitudinal expansion coefficient provided that all the relevant requirements of this regulation are continuously complied with under operating conditions.

## 3.2 Venturi tube with a cast convergent section

It is manufactured by casting in a sand mould or using other methods that leave the surface of the convergent section similar to that created by casting in sand. The throat is machined and the junctions between the cylindrical and conical sections are rounded.

### 3.2.1 Inlet section (A)

3.2.1.1 Length of the inlet section

The length of the cylindrical inlet section (A) shall not be less than $D$ or $0.25D + 250$ mm.

3.2.1.2 Internal diameter of the inlet section

The internal diameter $D$ of the cylindrical inlet section shall comply with the requirements specified in Article 2.2.

The diameter $D$ shall be measured at the level of the upstream pressure tappings and the number of measurements shall be at least equal to the number of pressure tappings (a minimum of four). The diameters shall be measured both near each pair of pressure tappings and between these pairs. Diameters shall also be measured along the length of the cylindrical inlet section, at levels other than at the pressure tappings. The mean value of the internal diameter $D$ of the inlet section (A) shall be determined as the simple arithmetic mean of all measurements performed.

3.2.1.3 Cylindricity of the inlet section

No diameter along the cylindrical inlet section may differ by more than 0.4 % from the value of the mean diameter.

3.2.1.4 Roughness of the inner surface of the inlet section

The inner surface may be left unmachined provided that the condition of the surface is the same as that of the convergent section (B).

### 3.2.2 Convergent section (B)

The convergent section is limited upstream by the plane containing the intersection of the cone frustum (B) with the inlet section (A) or their prolongations and downstream by the plane containing the intersection of the cone frustum (B) with the throat (C) or their prolongations.

3.2.2.1 Apex angle of the convergent section

The convergent section shall be conical and shall have an apex angle of 21° ± 1°.

3.2.2.2 Overall length of the convergent section

The overall length of the convergent section measured parallel to the centreline of the Venturi tube shall be approximately equal to 2.7 ($D - d$).

3.2.2.3 Profile of the convergent section

The convergent section is joined to the inlet section (A) by a curvature of a radius $R_1 = 1.375D \pm 0.275D$.

The deviation of the conical section of the convergent section from its ideal shape (represented e.g. by a shape template) may not exceed $0.004D$.

The inner surface of the conical section of the convergent section is taken as being a rotating surface if two diameters situated at the level perpendicular to the axis of revolution do not differ from the value of the mean diameter by more than 0.4 %.

It shall be checked in the same way that the joining curvature of radius $R_1$ is a rotating surface.

3.2.2.4 Inner surface roughness of the convergent section

The inner surface of the convergent section may be left unmachined, however, it may not have any surface defects or impurities. The roughness parameter *Ra* of the inner surface of the convergent section shall be $\leq 10^{-4} D$.

### 3.2.3 Throat (C)

The throat shall be cylindrical with a diameter *d*, limited upstream by the plane containing the intersection of the cone frustum (B) with the throat (C) or their prolongations, and downstream by the containing the intersection of the throat (C) with the cone frustum (E) or their prolongations. The distance between those two planes shall be equal to $d \pm 0.03d$. The throat is connected to the convergent section by a curvature of radius $R_2$ and to the divergent section by a curvature of radius $R_3$.

For Venturi tubes with a cast convergent section, the length of the cylindrical part of the throat shall be less than $d/3$. In addition, the length of the cylindrical section between the end of the joining curvature $R_2$ and the plane of the pressure tappings, as well as the length of the cylindrical section between the plane of the pressure tappings and the beginning of the joining curvature $R_3$ shall not be less than $d/6$.

3.2.3.1 Internal diameter of the throat

The diameter of the throat orifice *d* shall meet the requirements specified in Article 2.2.

The diameter *d* shall be measured in the plane of the throat pressure tappings. The number of measurements shall be at least equal to the number of pressure tappings (a minimum of four). The diameters shall be measured both near each pair of pressure tappings and between these pairs. Diameters shall also be measured along the length of the throat, at levels other than at the pressure tappings. The mean value of the internal throat diameter *d* shall be determined as the simple arithmetic mean of all measurements performed.

3.2.3.2 Throat cylindricity

The Venturi tube throat shall be cylindrical, no diameter in any cross-section measured in the cylindrical section of the throat may differ by more than 0.1 % of the value of the mean diameter.

3.2.3.3 Throat joints curvature profiles

The throat joint curvatures of radius $R_2$ and $R_3$ shall form the rotation surfaces. This requirement is satisfied when two diameters situated at the level perpendicular to the axis of revolution do not differ from the value of the mean diameter by more than 0.1 %.

The radius of curvature $R_2$ shall be equal to $3.625d \pm 0.125d$. The radius of curvature $R_3$ shall be between $5d$ and $15d$. The values of radii $R_2$ and $R_3$ shall be checked using a template.

The deviation between the template and the Venturi tube shall evolve in a regular way for each curvature so that the single maximum deviation that is measured occurs approximately midway along the template profile. The value of this maximum deviation shall not exceed $0.02d$.

3.2.3.4 Throat surface roughness

The roughness parameter *Ra* of the inner surface of the throat of the Venturi tube and the adjacent curvature shall be $\leq 10^{-4} d$.

### 3.2.4 Divergent section (E)

The divergent section shall be conical and may have an apex angle between 7° and 15°.

The smallest diameter of the divergent section shall not be less than the diameter of the throat of the Venturi tube.

If the outlet diameter of the divergent section is less than the diameter *D*, the Venturi tube is called 'truncated'. If the outlet diameter of the divergent section is equal to *D*, the Venturi tube is called 'not truncated'.

## 3.3 Venturi tube with a machined convergent section

It is manufactured in the same way as a Venturi tube with a cast convergent section, however, in this case the convergent section is machined, as is the throat and the conical inlet section. The junctions may, but do not have to be, rounded.

### 3.3.1 Inlet section (A)

3.3.1.1 Length of the inlet section

The length of the cylindrical inlet section (A) shall not be less than *D*.

3.3.1.2 Internal diameter of the inlet section

The internal diameter *D* of the cylindrical inlet section shall comply with the requirements specified in Article 2.2.

The diameter *D* shall be measured at the level of the upstream pressure tappings and the number of measurements shall be at least equal to the number of pressure tappings (a minimum of four). The diameters shall be measured both near each pair of pressure tappings and between these pairs. Diameters shall also be measured along the length of the cylindrical inlet section, at levels other than at the pressure tappings. The mean value of the internal diameter *D* of the inlet section (A) shall be determined as the simple arithmetic mean of all measurements performed.

3.3.1.3 Cylindricity of the inlet section

No diameter along the cylindrical inlet section may differ by more than 0.4 % from the value of the mean diameter.

3.3.1.4 Inner surface roughness of the inlet section

The inner surface of the inlet section shall have the same surface finish as the inner surface of the throat (C).

### 3.3.2 Convergent section (B)

The convergent section is limited upstream by the plane containing the intersection of the cone frustum (B) with the inlet section (A) or their prolongations and downstream by the plane containing the intersection of the cone frustum (B) with the throat (C) or their prolongations.

#### 3.3.2.1 Apex angle of the convergent section

The convergent section shall be conical and shall have an apex angle of 21° ± 1°.

#### 3.3.2.2 Overall length of the convergent section

The overall length of the convergent section measured parallel to the centreline of the Venturi tube shall be approximately equal to 2.7 ($D - d$).

#### 3.3.2.3 Profile of the convergent section

The convergent section is joined to the inlet section (A) by a curvature of radius $R_1 < 0.25D$ (ideally $R_1 = 0$).

The deviation of the conical section of the convergent section from its ideal shape (represented e.g. by a shape template) may not exceed $0.004D$.

The inner surface of the conical section of the convergent section is taken as being a rotating surface if two diameters situated at the level perpendicular to the axis of revolution do not differ from the value of the mean diameter by more than 0.4 %.

It shall be checked in the same way that the joining curvature of radius $R_1$ is a rotating surface.

#### 3.3.2.4 Inner surface roughness of the convergent section

The inner surface of the convergent section shall have the same surface finish as the inner surface of the throat (C).

### 3.3.3 Throat (C)

The throat shall be cylindrical with a diameter $d$, limited upstream by the plane containing the intersection of the cone frustum (B) with the throat (C) or their prolongations, and downstream by the containing the intersection of the throat (C) with the cone frustum (E) or their prolongations. The distance between those two planes shall be equal to $d \pm 0.03d$. The throat is connected to the convergent section by a curvature of radius $R_2$ and to the divergent section by a curvature of radius $R_3$.

For Venturi tubes with a machined convergent section, the length of the cylindrical section of the throat between the end of the curvature $R_2$ and at the level of pressure tappings in the throat shall not be less than $0.25d$ and the length of the cylindrical section between the level of the pressure tappings in the throat and the beginning of the joining curvature $R_3$ shall not be less than $0.3d$.

#### 3.3.3.1 Internal diameter of the throat

The diameter of the throat orifice $d$ shall meet the requirements specified in Article 2.2.

The diameter $d$ shall be measured at the level of the throat pressure tappings. The number of measurements shall be at least equal to the number of pressure tappings (a minimum of four). The diameters shall be measured both near each pair of pressure tappings and between these pairs. Diameters shall also be measured along the length of the throat, at levels other than at the pressure tappings. The mean value of the internal throat diameter $d$ shall be determined as the simple arithmetic mean of all measurements performed.

#### 3.3.3.2 Throat cylindricity

The Venturi tube throat shall be cylindrical, no diameter in any cross-section measured in the cylindrical section of the throat may differ by more than 0.1 % of the value of the mean diameter.

3.3.3.3 Throat joints curvature profiles

The throat joint curvatures of radius $R_2$ and $R_3$ shall form the rotating surfaces. This requirement is satisfied when two diameters situated at the level perpendicular to the axis of revolution do not differ from the value of the mean diameter by more than 0.1 %.

The radius of curvature $R_2$ shall be less than 0.25*d* (ideally equal to zero). The radius of curvature $R_3$ shall be less than 0.25*d* (ideally equal to zero). The values of radii $R_2$ and $R_3$ shall be checked using a template.

The deviation between the template and the Venturi tube shall evolve in a regular way for each curvature so that the single maximum deviation that is measured occurs approximately midway along the template profile. The value of this maximum deviation shall not exceed 0.02*d*.

3.3.3.4 Throat surface roughness

The roughness parameter *Ra* of the inner surface of the throat of the Venturi tube and the adjacent curvature shall be $\leq 10^{-4}\,d$.

### 3.3.4 Divergent section (E)

The divergent section shall be conical and may have an apex angle between 7° and 15°.

The smallest diameter of the divergent section shall not be less than the diameter of the throat of the Venturi tube.

If the outlet diameter of the divergent section is less than the diameter *D*, the Venturi tube is called 'truncated'. If the outlet diameter of the divergent section is equal to *D*, the Venturi tube is called 'not truncated'.

## 3.4 Venturi tube with a rough-welded sheet-iron convergent section

It is manufactured by means of welding. Tubes of large dimensions are typically not machined, in the case of smaller dimensions, the throat is machined.

### 3.4.1 Inlet section (A)

3.4.1.1 Length of the inlet section

The length of the cylindrical inlet section (A) shall not be less than *D*.

3.4.1.2 Internal diameter of the inlet section

The internal diameter *D* of the cylindrical inlet section shall comply with the requirements specified in Article 2.2.

The diameter *D* shall be measured at the level of the upstream pressure tappings and the number of measurements shall be at least equal to the number of pressure tappings (a minimum of four). The diameters shall be measured both near each pair of pressure tappings and between these pairs. Diameters shall also be measured along the length of the cylindrical inlet section, at levels other than at the pressure tappings. The mean value of the internal diameter *D* of the inlet section (A) shall be determined as the simple arithmetic mean of all measurements performed.

3.4.1.3 Cylindricity of the inlet section

No diameter along the cylindrical inlet section may differ by more than 0.4 % from the value of the mean diameter.

3.4.1.4 Inner surface roughness of the inlet section

The inner surface shall be clean, without dross and slag left after welding. The roughness parameter *Ra* of the inner surface of the inlet section shall be $\leq 5 \cdot 10^{-4} D$.

### 3.4.2 Convergent section (B)

The convergent section is limited upstream by the plane containing the intersection of the cone frustum (B) with the inlet section (A) or their prolongations and downstream by the plane containing the intersection of the cone frustum (B) with the throat (C) or their prolongations.

3.4.2.1 Apex angle of the convergent section

The convergent section shall be conical and shall have an apex angle of 21° ± 1°.

3.4.2.2 Overall length of the convergent section

The overall length of the convergent section measured parallel to the centreline of the Venturi tube shall be approximately equal to 2.7 ($D - d$).

3.4.2.3 Profile of the convergent section

There shall be no joining curvature between the inlet section (A) and the convergent section (B) other than that resulting from welding. There shall be no joining curvature between the convergent section (B) and the throat (C) other than that resulting from welding. The internal welded seams shall be flush with surrounding surfaces. They shall not be located in the vicinity of the pressure tappings.

The deviation of the conical section of the convergent section from its ideal shape (represented e.g. by a shape template) may not exceed 0.004*D*.

The inner surface of the conical section of the convergent section is taken as being a rotating surface if two diameters situated at the level perpendicular to the axis of revolution do not differ from the value of the mean diameter by more than 0.4 %.

3.4.2.4 Inner surface roughness of the convergent section

The inner surface shall be clean, without dross and slag left after welding. The roughness parameter *Ra* of the inner surface of the convergent section shall be $\leq 5 \cdot 10^{-4} D$.

### 3.4.3 Throat (C)

The throat shall be cylindrical with a diameter *d*, limited upstream by the plane containing the intersection of the cone frustum (B) with the throat (C) or their prolongations, and downstream by the containing the intersection of the throat (C) with the cone frustum (E) or their prolongations. The distance between those two planes shall be equal to $d \pm 0.03d$ for any type of Venturi tube.

3.4.3.1 Internal diameter of the throat

The diameter of the throat orifice *d* shall meet the requirements specified in Article 2.2.

The diameter *D* shall be measured at the level of the pressure tappings in the throat and the number of measurements shall be at least equal to the number of pressure tappings (a minimum of four). The diameters shall be measured both near each pair of pressure tappings and between these pairs. Diameters shall also be measured along the length of the throat, at levels other than at the pressure tappings. The mean value of the internal throat diameter *d* shall be determined as the simple arithmetic mean of all measurements performed.

3.4.3.2 Throat cylindricity

The Venturi tube throat shall be cylindrical, no diameter in any cross-section measured in the cylindrical section of the throat may differ by more than 0.1 % of the value of the mean diameter.

3.4.3.3 Venturi tube throat profile

There shall be no joining curvature between the convergent section (B) and the throat (C) other than that resulting from welding. There shall be no joining curvature between the throat (C) and the divergent section (E). The internal welded seams shall be flush with surrounding surfaces. They shall not be located in the vicinity of the pressure tappings.

The deviation between the template and the Venturi tube shall evolve in a regular way for each curvature so that the single maximum deviation that is measured occurs approximately midway along the template profile. The value of this maximum deviation shall not exceed 0.02*d*.

3.4.3.4 Throat surface roughness

The roughness parameter *Ra* of the inner surface of the throat of the Venturi tube shall be $\leq 10^{-4}\,d$.

### 3.4.4 Divergent section (E)

The divergent section shall be conical and may have an apex angle between 7° and 15°.

The smallest diameter of the divergent section shall not be less than the diameter of the throat of the Venturi tube.

If the outlet diameter of the divergent section is less than the diameter *D*, the Venturi tube is called 'truncated'. If the outlet diameter of the divergent section is equal to *D*, the Venturi tube is called 'not truncated'.

## 3.5 Differential pressure tappings for Venturi tubes

The pressure tappings upstream of the Venturi tube and in the throat shall be made in the form of separate pipe wall pressure tappings interconnected by annular chambers or piezometric rings, or a 'triple T' arrangement.

If $d \geq 33.3$ mm, the internal diameter of the pressure tappings shall be between 4 mm and 10 mm. Moreover, this diameter shall never be greater than 0.1*D* for the upstream pressure tappings and 0.13*d* for the throat pressure tappings.

If $d < 33.3$ mm, the internal diameter of the throat pressure tappings shall be between 0.1*d* to 0.13*d* and the diameter of the upstream pressure tappings shall be between 0.1*d* and 0.1*D*.

At least four pressure tappings shall be provided for a pressure measurement upstream of the Venturi tube and in the throat. The centrelines of the pressure tappings shall meet the centreline of the Venturi tube, shall form equal angles with each other and shall be contained in planes perpendicular to the centreline of the Venturi tube.

At the outlet, the opening of the pressure tapping shall be circular. The edges shall be flush with the pipe wall and free from burrs. If joining curvatures are required, the radius shall not exceed one-tenth of the diameter of the pressure tapping. The pressure tappings shall be cylindrical over a length at least 2.5 times the internal diameter of the tapping (measured from the inner wall of the pipeline).

For Venturi tubes with a cast convergent section, the spacing between the upstream pressure tappings situated on the inlet section and the plane of intersection of the inlet section (A) and the prolongation of the convergent section (B) shall be equal to

$0.5D \pm 0.25D$ for 100 mm < *D* < 150 mm;

$0{,}5D\ ^{0}_{-0{,}25D}$ for 150 mm < *D* < 800 mm.

For Venturi tubes with a machined convergent section and with a rough-welded sheet-iron convergent section, the spacing between the upstream pressure tappings and the plane of intersection of the inlet section (A) and the convergent section (B) or their prolongations shall be equal to $0.5D \pm 0.05D$.

The spacing between the plane containing the axes of the throat pressure tappings and the intersection plane between the convergent section and the throat (or their prolongations) shall be equal to $0.5d \pm 0.02d$ for all Venturi tubes described above.

The area of the free cross-section of the annular chamber of the pressure tappings shall be greater than or equal to half the total surface area of the tapping openings connecting the chamber to the pipe.

The other technical requirements for the design of the pressure tappings are specified under the relevant requirements of the notified standards attached to this general measure.

## 3.6 Straight lengths of pipe

### 3.6.1 Design

The minimum straight lengths of pipe upstream of the Venturi tube to be complied with in specific applications shall be determined according to the diameter ratio $\beta$ and the type and mutual arrangement of at least two adapting pieces placed upstream of the Venturi tube.

The straight length of pipe between the first adapting piece upstream of the Venturi tube and the actual Venturi tube may be made of one or more pieces, however, the part of the pipeline up to the length of $2D$ upstream of the Venturi tube shall be made of one piece.

### 3.6.2 Pipeline circularity and cylindricity

The pipeline shall be cylindrical over a length of at least $2D$ upstream of the inlet section of the Venturi tube. The pipeline meets the circularity and cylindricity requirements if none of the measured internal pipe diameters in any plane differs by more than 2 % from the mean value of the measured pipe diameters.

At the point of connection to the Venturi tube, the mean pipeline diameter shall be within 1 % of the diameter $D$ of the inlet section of the Venturi tube.

The internal pipe diameter downstream of the Venturi tube shall not be less than 90 % of the diameter of the end of the divergent section of the Venturi tube.

### 3.6.3 Quality of the inner surface of the pipeline upstream of the Venturi tube

The inner surface of the pipeline shall meet the specified surface roughness requirements for at least the minimum straight length upstream of the Venturi tube determined by the basic design of the gas flow meter (see Article 3.1). The inner surface of the pipeline over the length of $2D$ upstream of the Venturi tube (measured from the front end of the inlet section of the Venturi tube) shall have a relative roughness of $Ra/D \leq 3.2 \cdot 10^{-4}$.

### 3.6.4 Coaxiality of the Venturi tube

The spacing between the centreline of the Venturi tube and the axis of the upstream pipeline (measured at the level of the pipe's connection to the inlet section of the Venturi tube) shall be less than $0.005D$.

The maximum deviation from angular coaxiality between the Venturi tube and the upstream pipeline shall be 1°.

The sum of the deviation due to mounting and half of the permitted deviation of the internal diameter $D$ (see Article 3.6.2 – the equality of diameters at the point of connection of the pipe to the inlet section of the Venturi tube) shall be less than $0.0075D$.

## 3.7 Installation requirements

The installation position of the Venturi tube shall be clearly defined by its design or schematically indicated directly on the Venturi tube.

# 4 Measuring instrument markings

## 4.1 General

All inscriptions and markings shall be readily visible, legible and indelible under normal conditions and shall be the source of information necessary for the faultless implementation of the Venturi tube gas flow sensor into the gas flow quantity measuring system in relation to the other components of the measurement system.

## 4.2 Markings

### 4.2.1 Markings on the Venturi tube

The Venturi tube shall carry the following information:

a) serial number;
b) the value of the internal diameter $D_{20}$ of the inlet section of the Venturi tube relative to the reference temperature of 20 °C;
c) the type-approval mark;
d) suitable marking to identify the type and placement of the differential pressure tappings, if pressure tappings are a fixed component of the design of the Venturi tube.

In cases where the above information will not be visible once the Venturi tubes have been incorporated into the pipe, the Venturi tube shall also carry a separate additional label with the relevant information, which will form part of the system securing the Venturi tube against unauthorised disassembly or replacement.

In cases where the Venturi tube could be incorrectly installed in terms of the direction of gas flow, the flow direction shall be indicated on the Venturi in such a manner that it cannot be confused.

### 4.2.2 Marking of Venturi tube gas flow sensors

Venturi tube gas flows sensors shall carry the following information:

a) the name of the manufacturer and type (design variant);
b) serial number and year of manufacture;
c) the value of the internal diameter $D_{20}$ of the inlet section of the Venturi tube relative to the reference temperature of 20 °C;
d) the value of the internal diameter $d_{20}$ of the Venturi tube throat relative to the reference temperature of 20 °C;
e) the type-approval mark;
f) nominal size DN/nominal pressure PN;
g) indication of the direction of flow;
h) suitable marking to identify the type and placement of the differential pressure tappings, if pressure tappings are a fixed component of the straight lengths of pipe;
i) the measured flow range or the value of maximum flow.

This information shall be placed on a part of the gas flow sensor which is permanently connected to the straight pipe section 0.5$D$ upstream of the Venturi tube (installation chamber, connection flange upstream of the Venturi tube, straight length of pipe over a maximum of 2$D$ upstream of the Venturi tube).

If the straight length of pipe upstream of the Venturi tube comprises multiple pipeline sections in the basic design of the gas flow sensor, all of these sections shall be marked with the type-approval mark. Any important separate sections of the Venturi tube gas flow sensor shall generally be marked with the type-approval mark.

### 4.3 Marking with official marks

Suitable spaces shall be provided for placing the type-approval mark and the official mark(s).

It shall be possible to secure the Venturi tube against unauthorised disassembly or replacement.

## 5 Type-approval of measuring instruments

The process of type-approval of Venturi tube gas flow sensors comprises the following tests and activities:

a) external inspection;
b) check of the geometric parameters.

### 5.1 External inspection

The external inspection shall include the following:

- the completeness of the required technical documentation;
- the conformity of the metrological and technical characteristics specified by the manufacturer in the documentation with the technical and metrological requirements of this regulation specified in Chapters 2 and 3;
- the Venturi tube, pressure tappings and straight lengths of pipe in terms of any mechanical damage or traces of corrosion which would preclude further testing; and
- specification of the spaces where the basic geometric parameters of the Venturi tube gas flow sensor will be indicated and spaces for placing official marks.

### 5.2 Check of the geometric parameters

#### 5.2.1 Test equipment

Suitable equipment with valid metrological traceability shall be used to check the geometric parameters.

#### 5.2.2 Reference ambient temperature for testing

5.2.2.1 Venturi tube

The test ambient temperature shall be within the interval of (18 to 22) °C and changes in ambient temperature may not exceed 2 °C during the period of the test.

5.2.2.2 Straight lengths of pipe

Pipe ≤ DN 300: The test ambient temperature shall be within the interval of (15 to 25) °C and changes in ambient temperature may not exceed 2 °C during the period of measurement.

Pipe ≤ DN 300: The test ambient temperature shall be within the interval of (10 to 30) °C and changes in ambient temperature may not exceed 5 °C during the period of the test.

#### 5.2.3 Check of the geometric parameters of Venturi tubes

The value of the internal diameter $D_{20}$ of the inlet section of the Venturi tube shall be established in accordance with the requirement under Articles 2.2 and 3.2.1.2, or, if applicable, 3.3.1.2 or 3.4.1.2, and shall be relative to the reference temperature of 20 °C.

The value of the internal diameter $d_{20}$ of the throat of the Venturi tube shall be established in accordance with the requirement under Articles 2.2 and 3.2.3.1, or, if applicable, 3.3.3.1 or 3.4.3.1 and shall be relative to the reference temperature of 20 °C.

5.2.3.1 Check of the geometric parameters of Venturi tubes with a cast convergent section

For Venturi tubes with a cast convergent section, the following additional parameters shall be checked:

- the length of the inlet section of the Venturi tube (see Article 3.2.1.1);
- the cylindricity of the inlet section of the Venturi tube (see Article 3.2.1.3);
- the inner surface roughness of the inlet section of the Venturi tube (see Article 3.2.1.4);
- the apex angle of the convergent section of the Venturi tube (see Article 3.2.2.1);
- the overall length of the convergent section of the Venturi tube (see Article 3.2.2.2);
- the design and inner surface roughness of the convergent section of the Venturi tube (see Articles 3.2.2.3 and 3.2.2.4);
- the internal diameter of the throat of the Venturi tube (see Article 3.2.3.1);
- the cylindricity of the throat of the Venturi tube (see Article 3.2.3.2);
- the design and inner surface roughness of the throat of the Venturi tube (see Articles 3.2.3, 3.2.3.3 and 3.2.3.4);
- the design and apex angle of the divergent section of the Venturi tube (see Article 3.2.4).

5.2.3.2 Check of the geometric parameters of Venturi tubes with a machined convergent section

For Venturi tubes with a machined convergent section, the following additional parameters shall be checked:

- the length of the inlet section of the Venturi tube (see Article 3.3.1.1);
- the cylindricity of the inlet section of the Venturi tube (see Article 3.3.1.3);
- the inner surface roughness of the inlet section of the Venturi tube (see Article 3.3.1.4);
- the apex angle of the convergent section of the Venturi tube (see Article 3.3.2.1);
- the overall length of the convergent section of the Venturi tube (see Article 3.3.2.2);
- the design and inner surface roughness of the convergent section of the Venturi tube (see Articles 3.3.2.3 and 3.3.2.4);
- the internal diameter of the throat of the Venturi tube (see Article 3.3.3.1);
- the cylindricity of the throat of the Venturi tube (see Article 3.3.3.2);
- the design and inner surface roughness of the throat of the Venturi tube (see Articles 3.3.3, 3.3.3.3 and 3.3.3.4);
- the design and apex angle of the divergent section of the Venturi tube (see Article 3.3.4).

5.2.3.3 Check of the geometric parameters of Venturi tubes with a rough-welded convergent section

For Venturi tubes with a rough-welded sheet-iron convergent section, the following additional parameters shall be checked:

- the length of the inlet section of the Venturi tube (see Article 3.4.1.1);
- the cylindricity of the inlet section of the Venturi tube (see Article 3.4.1.3);
- the inner surface roughness of the inlet section of the Venturi tube (see Article 3.4.1.4);
- the apex angle of the convergent section of the Venturi tube (see Article 3.4.2.1);
- the overall length of the convergent section of the Venturi tube (see Article 3.4.2.2);
- the design and inner surface roughness of the convergent section of the Venturi tube (see Articles 3.4.2.3 and 3.4.2.4);
- the internal diameter of the throat of the Venturi tube (see Article 3.4.3.1);

- the cylindricity of the throat of the Venturi tube (see Article 3.4.3.2);
- the design and inner surface roughness of the throat of the Venturi tube (see Articles 3.4.3, 3.4.3.3 and 3.4.3.4);
- the design and apex angle of the divergent section of the Venturi tube (see Article 3.2.4).

#### 5.2.4 Check of the geometric parameters of the straight lengths of pipe upstream of the Venturi tube

For the straight lengths of pipe upstream of the Venturi tube, the following geometric parameters shall be checked:

- the circularity and cylindricity of the pipe (see Article 3.6.2);
- the inner surface roughness of the pipe (see Article 3.6.3);
- the coaxiality of the Venturi tube (see Article 3.6.4).

#### 5.2.5 Check of the geometric parameters of the differential pressure tappings

Compliance with the requirements for differential pressure tappings, depending on the type of the Venturi tube pursuant to Article 3.5 and the manufacturer's specifications, is ascertained.

## 6 Initial verification

The initial verification of Venturi tube gas flow meters and their components shall comprise the following tests and activities:

- visual inspection;
- test of metrological characteristics;
- indication of the basic geometric parameters on the relevant part of the Venturi tube gas flow sensor.

### 6.1 Visual inspection

The purpose of the visual inspection is to check that:

- the design of the Venturi tube gas flow sensor conforms to the approved type;
- the Venturi tube, the pressure tappings and the straight lengths of pipe are not mechanically damaged and bear no traces of corrosion which would preclude further testing;
- the content and implementation of markings and inscriptions correspond to the information and requirements specified in the type-approval certificate for the measuring instrument.

If the Venturi tube gas flow sensor fails to meet the external inspection requirements, no further tests are performed.

### 6.2 Check of the geometric parameters

#### 6.2.1 Test equipment

Suitable equipment with valid metrological traceability shall be used to check the geometric parameters.

#### 6.2.2 Reference ambient temperature for testing

The ambient temperature requirements pursuant to Article 5.2.2 shall apply to testing.

### 6.2.3 Check of the geometric parameters of Venturi tubes

The value of the internal diameter $D_{20}$ of the inlet section of the Venturi tube shall be established in accordance with the requirement under Articles 2.2 and 3.2.1.2, or, if applicable, 3.3.1.2 or 3.4.1.2, and shall be relative to the reference temperature of 20 °C.

The value of the internal diameter $d_{20}$ of the throat of the Venturi tube shall be established in accordance with the requirement under Articles 2.2 and 3.2.3.1, or, if applicable, 3.3.3.1 or 3.4.3.1 and shall be relative to the reference temperature of 20 °C.

6.2.3.1 Check of the geometric parameters of Venturi tubes with a cast convergent section

For Venturi tubes with a cast convergent section, the following additional parameters shall be checked during initial verification:

- the length of the inlet section of the Venturi tube (see Article 3.2.1.1);
- the cylindricity of the inlet section of the Venturi tube (see Article 3.2.1.3);
- the inner surface roughness of the inlet section of the Venturi tube (see Article 3.2.1.4);
- the apex angle of the convergent section of the Venturi tube (see Article 3.2.2.1);
- the overall length of the convergent section of the Venturi tube (see Article 3.2.2.2);
- the design and inner surface roughness of the convergent section of the Venturi tube (see Articles 3.2.2.3 and 3.2.2.4);
- the internal diameter of the throat of the Venturi tube (see Article 3.2.3.1);
- the cylindricity of the throat of the Venturi tube (see Article 3.2.3.2);
- the design and inner surface roughness of the throat of the Venturi tube (see Articles 3.2.3, 3.2.3.3 and 3.2.3.4);
- the design and apex angle of the divergent section of the Venturi tube (see Article 3.2.4).

6.2.3.2 Check of the geometric parameters of Venturi tubes with a machined convergent section

For Venturi tubes with a machined convergent section, the following additional parameters shall be checked during initial verification:

- the length of the inlet section of the Venturi tube (see Article 3.3.1.1);
- the cylindricity of the inlet section of the Venturi tube (see Article 3.3.1.3);
- the inner surface roughness of the inlet section of the Venturi tube (see Article 3.3.1.4);
- the apex angle of the convergent section of the Venturi tube (see Article 3.3.2.1);
- the overall length of the convergent section of the Venturi tube (see Article 3.3.2.2);
- the design and inner surface roughness of the convergent section of the Venturi tube (see Articles 3.3.2.3 and 3.3.2.4);
- the internal diameter of the throat of the Venturi tube (see Article 3.3.3.1);
- the cylindricity of the throat of the Venturi tube (see Article 3.3.3.2);
- the design and inner surface roughness of the throat of the Venturi tube (see Articles 3.3.3, 3.3.3.3 and 3.3.3.4);
- the design and apex angle of the divergent section of the Venturi tube (see Article 3.3.4).

6.2.3.3 Check of the geometric parameters of Venturi tubes with a rough-welded convergent section

For Venturi tubes with a rough-welded sheet-iron convergent section, the following additional parameters shall be checked during initial verification:

- the length of the inlet section of the Venturi tube (see Article 3.4.1.1);
- the cylindricity of the inlet section of the Venturi tube (see Article 3.4.1.3);
- the inner surface roughness of the inlet section of the Venturi tube (see Article 3.4.1.4);

- the apex angle of the convergent section of the Venturi tube (see Article 3.4.2.1);
- the overall length of the convergent section of the Venturi tube (see Article 3.4.2.2);
- the design and inner surface roughness of the convergent section of the Venturi tube (see Articles 3.4.2.3 and 3.4.2.4);
- the internal diameter of the throat of the Venturi tube (see Article 3.4.3.1);
- the cylindricity of the throat of the Venturi tube (see Article 3.4.3.2);
- the design and inner surface roughness of the throat of the Venturi tube (see Articles 3.4.3, 3.4.3.3 and 3.4.3.4);
- the design and apex angle of the divergent section of the Venturi tube (see Article 3.2.4).

### 6.2.4 Check of the geometric parameters of the straight lengths of pipe upstream of the Venturi tube

For straight lengths of pipe, the following geometric parameters shall be checked during initial verification:

- the circularity and cylindricity of the pipe (see Article 3.6.2);
- the inner surface roughness of the pipe (see Article 3.6.3);
- the coaxiality of the Venturi tube (see Article 3.6.4).

### 6.2.5 Check of the geometric parameters of the differential pressure tappings

During initial verification, compliance with the requirements for the differential pressure tappings, depending on the type of the Venturi tube pursuant to Article 3.5 and the manufacturer's specifications, is ascertained.

### 6.2.6 Indication of the basic geometric parameters on the measuring instrument

The value of the internal diameter of the throat orifice of the Venturi tube ($d_{20}$) and the internal diameter of the inlet section of the Venturi tube ($D_{20}$) specified pursuant to Article 6.2.3 shall be indicated in a legible and indelible manner in a suitable space on the Venturi tube gas flow sensor in accordance with Article 4.2.

## 7 Subsequent verification

The procedure for subsequent verification of the Venturi tube is identical to that for initial verification pursuant to Article 6.2.3.

Subsequent verification of the straight lengths of pipe of Venturi tube gas flow sensors is not performed.

Long-term compliance with the operating conditions, including keeping the inner surface of the pipes in appropriate condition and clean, shall be ensured by the user of the measuring instrument. For this purpose, the user of the measuring instrument shall perform or ensure the performance of visual inspections of the condition of the inner surface of the pipe at intervals which take into account the operating conditions and the type of the gas medium being measured. In addition, this inspection shall always be performed prior to installing the Venturi tube.

## 8 Measuring instrument examination

When examining measuring instruments pursuant to § 11a of the Metrology Act at the request of a person who may be affected by incorrect measurement, the procedure under Chapter 6 shall be followed. The last sentence of Article 6.1 shall not apply.

# 9 Notified standards

For the purposes of specifying the metrological and technical requirements for measuring instruments and specifying the testing methods for their type-approval and verification arising from this general measure, the CMI shall notify Czech technical standards, other technical standards or technical documents of international or foreign organisations, or other technical documents containing more detailed technical requirements (hereinafter referred to as 'notified standards'). The CMI shall publish a list of these notified standards attached to the relevant measures, together with the general measure, in a manner accessible to the public (at www.cmi.cz).

Compliance with notified standards or parts thereof shall be considered, to the extent and under the conditions laid down in this general measure, as compliance with those requirements laid down in this measure to which these standards or parts thereof apply.

Compliance with notified standards is one way of demonstrating compliance with the requirements. These requirements may also be met by using another technical solution guaranteeing an equivalent or higher level of protection of legitimate interests.

## II.

## G R O U N D S

The CMI has issued this general measure laying down metrological and technical requirements for legally controlled measuring instruments and tests for the type-approval and verification of legally controlled measuring instruments – 'Venturi tube gas flow sensors' – in accordance with § 14(1)(j) of the Metrology Act to implement § 6(2), § 9(1) and (9), and § 11a(3) of the Metrology Act.

Under item 1.3.11(c) in the Annex 'List of the Types of Legally Controlled Measuring Instruments' to Implementing Decree No 345/2002 specifying the measuring instruments whose verification is mandatory and measuring instruments subject to type-approval, as amended, this type of measuring instrument is classified as an instrument subject to mandatory verification.

This legislation (general measure) will be notified in accordance with Directive (EU) 2015/1535 of the European Parliament and of the Council of 9 September 2015 laying down a procedure for the provision of information in the field of technical regulations and of rules on Information Society services.

## III.

## I N S T R U C T I O N S

In accordance with § 172(1) APC, in conjunction with § 39(1) APC, the CMI has stipulated a time limit for comments of 30 days from the date of posting the draft on the official notice board. Comments submitted after this time limit will not be considered.

The persons concerned are hereby invited to comment on this draft general measure. With a view to the provisions of § 172(4) APC, the comments are to be submitted in writing.

Pursuant to the provisions of § 174(1) APC, in conjunction with the provisions of § 37(1) APC, it must be clearly stated who is submitting the comments, which general measure the comments concern, how the draft contradicts legislation or how the general measure is inaccurate. The comments must also contain the signature of the person making the comments.

The supporting documents for this draft general measure may be consulted at the Czech Metrology Institute, Legal Metrology Department, Okružní 31, 638 00 Brno, after making arrangements by telephone.

This draft general measure shall be posted for 15 days.

Czech Metrology Institute
Director General